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(71) Applicant(s)
Airscrew Howden Limited

(Incorporated in the United Kingdom)

111 Windmill Road, SUNBURY-ON-THAMES, Middlesex, TW16 7EF, United Kingdom

(72) Inventor(s)
Dennis Griffin

(74) Agent and/or Address for Service
Lloyd Wise, Tregear & Co
Commonwealth House, 1-19 New Oxford Street, LONDON, WC1A 1LW, United Kingdom

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(56) Documents Cited
GB 2173745 A GB 0480692 A GB 0478427 A
GB 0470088 A GB 0327101 A GB 0195991 A
US 4240599 A

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UK CL (Edition N) A6S , B7G
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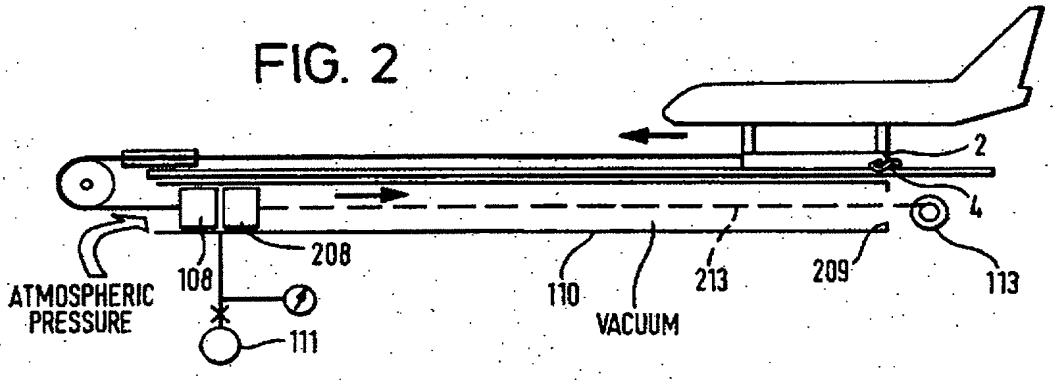
(54) Launching projectiles

(57) A collapsing vacuum behind the piston of a piston and cylinder arrangement may be used to provide a forward propelling force to launch a projectile such as an RPV or VAV. Apparatus for launching an unmanned air vehicle or other projectile may comprise a tension gas spring consisting of a cooperating piston 108 and cylinder 110 arrangement in which at least a partial vacuum may be created behind the piston 108, a tension element (rope) coupled to the piston and a releasable coupling (e.g. trolley) for interconnecting the tension element and the vehicle or other projectile and adapted to be released at launch velocity, whereby collapse of said vacuum is effective to apply a forward propelling force to the projectile via the tension element. The vacuum may be generated between the piston 108 and a contra-piston 208, actuated by a winch 113.

FIG. 2



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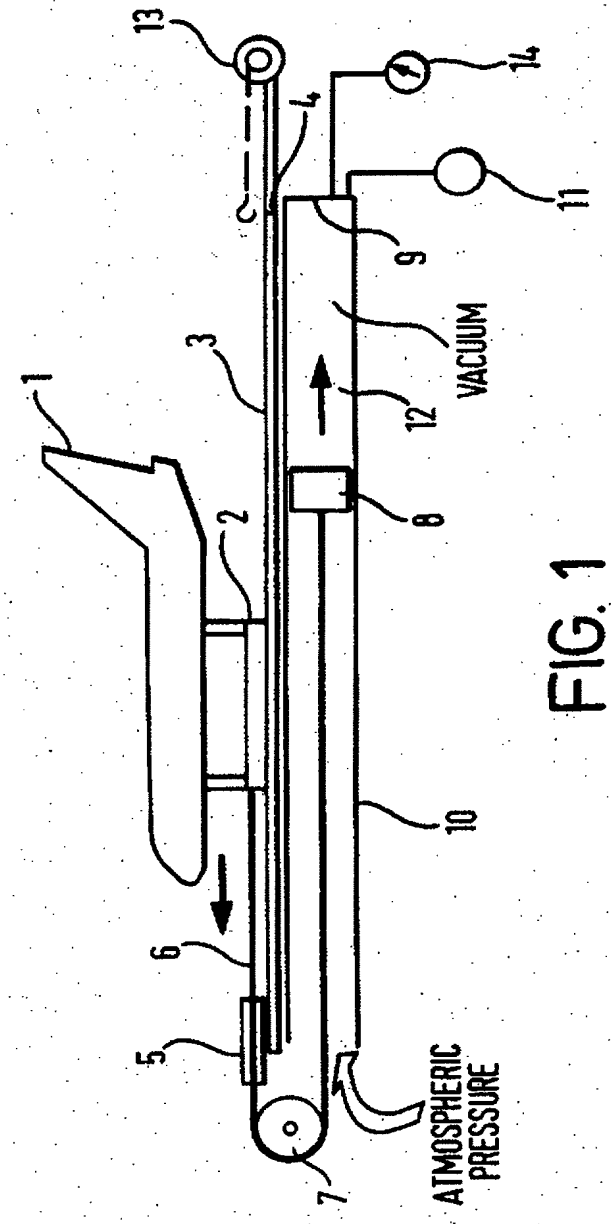
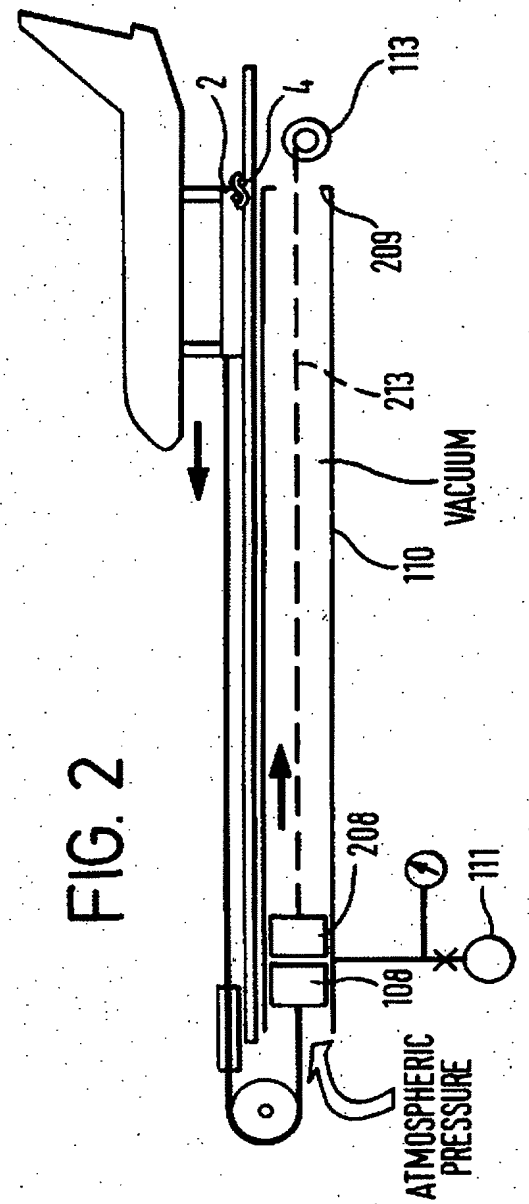


FIG. 1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4
113
209
213
VACUUM
110
208
111
108
ATMOSPHERIC PRESSURE

FIG. 2

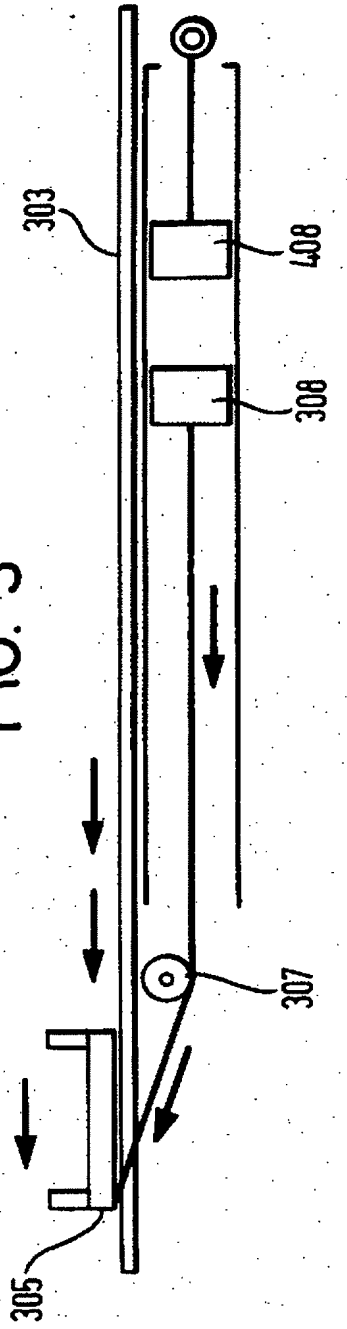
303
408
308
307
305

FIG. 3

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LAUNCHING PROJECTILES

This invention is concerned with launching projectiles, such as (but not restricted to) remote piloted vehicles (RPVs), also known as unmanned air vehicles (UAVs) and as unmanned aircraft (UMAs).

A wide variety of different launch systems are available for RPVs.

One such system is that described in GB-A-2132577 which discloses a flywheel operated launcher. While successful and readily controllable, this launcher has proved relatively expensive in comparison with perhaps technically less successful competing designs. Such designs have included bungee launchers and gas guns. The flywheel system involves the use of heavy masses to provide in effect a store of inertial momentum. The bungee and gas gun systems operate on a stored energy principle. The use of relatively large stores of potential energy in this way is inherently dangerous. The stored energy systems such as the gas gun or bungee, while relatively simpler in design than the flywheel systems suffer from lack of control of the initial rate of change of accelerating forces (the "jerk") which can prove excessive and damage the RPV. In addition, as the energy is released, the accelerating force reduces markedly.

The present invention has arisen from our work seeking to overcome the difficulties inherent in all these previous designs.

As will be clear from the description which follows below, we have found that it is possible to use atmospheric pressure to launch an RPV to flying speed by allowing vacuum in a piston and cylinder arrangement to collapse, thereby pulling on a cable or other tension element to propel the RPV forwardly.

Accordingly, the invention provides, in its broadest aspect, use of a collapsing at least partial vacuum behind the piston of a piston and cylinder arrangement to provide a forward propelling force to launch a projectile.

In a more specific aspect of the invention, there is provided use of a tension gas spring to launch a projectile, the tension gas spring comprising a cooperating piston and cylinder arrangement in which at least a partial vacuum is created behind the piston and the piston is coupled to the projectile via a tension element a releasable coupling, whereby collapse of the vacuum is effective to apply a forward propelling force to the projectile via the tension element and the releasable coupling, the coupling being released at launch velocity of the projectile.

As will be appreciated, a tension gas spring working against a vacuum will provide a substantially constant accelerating force over the greater part of its stroke.

The invention may also be embodied in the form of a launcher, and the invention accordingly further provides in a yet alternative aspect thereof, apparatus for launching an unmanned air vehicle or other projectile, comprising: a tension gas spring consisting of a cooperating piston and cylinder arrangement in which at least a partial vacuum may be created behind the piston; a tension element coupled to the piston; and a releasable coupling for interconnecting the tension element and a vehicle or other projectile and adapted to be released at launch velocity; whereby collapse of said vacuum is effective to apply a forward propelling force to the projectile via the tension element.

The tension element may simply comprise an appropriate cable. The vehicle or other projectile may simple be mounted on a trolley which is attached to the end of the cable remote from the piston, this trolley comprising the

releasable coupling. The trolley may be wheeled or be arranged to run on rails, but in either event, the vehicle is released from the trolley when the trolley hits a buffer stop and is brought to a halt.

The piston and cylinder arrangement may comprise a simple cylinder having a closed end. In an alternative arrangement that "closed" end may be coupled to a suction pump. In another arrangement, the cylinder may have two pistons, namely the primary piston and a contra piston and the vacuum may be created behind the primary piston by moving the contra piston along the length of the cylinder to provide a vacuum filled space between the two pistons.

The invention is hereinafter more particularly described by way of example only with reference to the accompanying drawings in which:-

Fig. 1 is a generally schematic view of a first embodiment of apparatus constructed in accordance with the present invention;

Fig. 2 is a generally similar but equally schematic view of an alternative embodiment also constructed in accordance with this present invention; and

Fig. 3 is a further partial schematic view of a variation of the arrangement shown in Fig. 2.

In the launch system illustrated in Fig. 1, an RPV 1 is mounted on a trolley 2 which runs on rails 3 between a start position defined by latch 4 and a stop position defined by trolley buffer stop 5. Coupled to the trolley 2 is a tension cable 6 which passes over a pulley 7 and is connected to piston 8 of a cooperating piston and cylinder arrangement. In this illustrated embodiment, the "closed"

end 9 of cylinder 10 is coupled to a suction pump 11 for creating or enhancing the level of vacuum in chamber 12 behind piston 8 between the piston and the "closed" end 9 of the cylinder. Vacuum in the chamber 12 may be created by simply pulling the piston 8 down the cylinder by cable 6, using winch 13 in cooperation with trolley 2 in effect to wind up the system. Alternatively, with the trolley 2 already held by latch 4 in its start position, a vacuum may be created in the space 12 by use of the suction pump 11. The first of these two alternatives is much quicker to load and, provided that the seal between the piston 8 and the cylinder 10 is sufficiently good will provide an adequate vacuum. The suction pump 11, in this arrangement, is employed to enhance the vacuum, the level of which may be gauged by vacuum gauge 14 coupled to the "closed" end 9 of the cylinder 10.

Since the level of vacuum achieved is important for success of the launch, the seal between the piston 8 and the cylinder 10 is of considerable importance. Arrangements which provide a permanent seal between the piston and the cylinder rather than simply having seal rings and the like on the piston are to be preferred. One such arrangement, already known per se is a rolling diaphragm seal. Such a seal effectively comprises an annular diaphragm, the inner radius of which is permanently affixed to the outer surface of the piston and the outer circumferential edge of which is permanently connected to the cylinder either on its internal surface or by being rolled over the distal end and affixed to the exterior. For ease of illustration in Fig. 1, the preferred rolling diaphragm seal has been omitted.

To launch an RPV 1 using the system illustrated in Fig. 1, the following sequence of steps would be carried out:

a) With no vehicle mounted on the trolley, suction is applied by pump 11 to the closed end 9 of cylinder 10

to draw the piston to its end stop excluding as much entrapped air as possible and energizing the seals.

b) The winch 13 is connected to the launch trolley 2 and pulled back to the pre-launch energized position, the suction pump first having been isolated. This creates a good vacuum in the cylinder 10 behind piston 8.

c) The trolley 2 is latched by latch 4 in its pre-launch position, a safety pin being inserted to inhibit trolley motion. The winch 13 is then disconnected.

d) The RPV is loaded on the trolley, its engine started and its controls checked. The safety pin is then removed so that the trolley would be free to move on release of the latch.

e) The level of vacuum in the cylinder is checked by means of gauge 14 to ensure that an adequate level of vacuum to launch the vehicle to its launch velocity is present.

f) The latch 14 is released via a lanyard. Piston 8 is then drawn back into its cylinder 10 accelerating the trolley 2 and RPV 1. The trolley 2 comes to a halt when it hits trolley buffer stop 5 and the RPV 1 is launched.

We have found that the system can readily be engineered to provide an appropriate launch velocity for an RPV. In one practical embodiment, a cylinder tube of internal diameter 410 mm and with a length of 3.5 m provides a near constant vacuum pull of 11880N, at a differential pressure of 0.09 MPa. This is sufficient to accelerate a total moving mass of 120 Kg to 24 m/s in a distance of 3 m.

A similar effect can be achieved by using a multiplicity of smaller diameter tubes (for example four tubes each of 205 mm diameter). In this case, of course, the cable 6 either comprises a number of separate cables running in parallel or divides in order to provide a separate tension element for the piston 8 of each of the parallel operating smaller piston and cylinders. Smaller cylinder tubes are easier to manufacture and can employ significantly thinner wall thicknesses. For best results, both to ensure that the piston is fully retracted prior to operation and to enhance the vacuum, a suction pump 11 would be applied to draw residual air from behind the piston 8 in each of these parallel cylinders.

In the alternative embodiment of Fig. 2, the vacuum is not drawn by a winch connected to the trolley and drawing the trolley back to its launch position. Instead, the winch, here designated 113 forms part of the piston and cylinder arrangement. Mounted in the cylinder 110 is a primary piston 108 which corresponds to piston 8 of the Fig. 1 arrangement, and also a second piston 208 which, as explained below, operates as a contra piston. The cylinder 110 does not have a closed end in this embodiment, winch 113 being connected by a winch cable 213 to contra piston 208.

In the arrangement of Fig. 2, the trolley is first moved to its start position and held by latch 4. This does not require the use of a powerful winch as in the Fig. 1 arrangement because this movement to the start position is not against a vacuum. With the trolley 2 in this start position, piston 108 is positioned adjacent the distal end of cylinder 110. Suction pump 111 in this embodiment is coupled to cylinder 110 just behind piston 108 in this forward position. Operation of the suction pump draws contra piston 208 into contact with the principal piston 108. Winch 113 is then operated to draw contra piston 208 down the cylinder 110 to its proximal end 209 which, of

course, is not closed in this arrangement. The vacuum is enhanced and a vacuum space created behind piston 108 between that piston and the contra piston 208. Winch 113 and/or contra piston 208 are latched to prevent reverse movement of the contra piston 208 when it reaches proximal end 209 of cylinder 110. Operation is then as with the Fig. 1 arrangement, latch 4 being released and the trolley moving forwardly under tension in the cable 6 as the vacuum behind piston 108 collapses, while contra piston 208 is held.

In this arrangement, the RPV engine can be started prior to the winching operation so that there is less possibility of vacuum decay due to leakage since the launcher can be released as soon as contra piston 208 reaches proximal end 209 of cylinder 110. The possibility of the winch being left connected to the trolley (which would of course inhibit launch) which is possible in the Fig. 1 arrangement (unless appropriate interlocks are provided in the system preventing the next stage of operation until the winch 13 has been released), is avoided because in the Fig. 2 arrangement, winch 213 remains permanently coupled to contra piston 208.

In the arrangements both of Figs. 1 and 2, the trolley on which the RPV is mounted is brought to a halt by coming up against a buffer stop. Fig. 3 illustrates a variation of the Fig. 2 arrangement which avoids the need for a buffer stop. There being no buffer, the trolley 305 continues to travel along the rail 303 after the trolley comes level with pulley 307. From this point on, the momentum of the trolley pulls against the piston 308 and tends to recreate vacuum between that piston and the contra piston 408, thereby creating a decelerating force on the trolley both launching the RPV (not shown in Fig. 3) and rapidly bringing the trolley to a halt. If the contra piston is released during this phase of the travel in effect by unlocking the winch, the contra piston can be drawn with the piston back towards

its starting position, thereby partially re-arming the device for the next launch. There will of course be significant friction losses in the system so that the trolley comes to a halt rather than oscillating about the central position of the pulley.

We have found that sealing of the system is most crucial in the first few centimetres of motion of the piston 8 in the Fig. 1 arrangement or the dynamic piston 108 in the Fig. 2 arrangement. For this reason, our preferred embodiment employs a special close-tolerance section in the forward end of the cylinder and an additional high-integrity O-ring seal to cover these first few centimetres of motion. Thereafter, once the piston is accelerating, seal integrity is less vital and a lip seal may suffice. In the Fig. 2 arrangement, the contra piston 208 may be provided with a conventional multi-stage O-ring seal as its friction with the cylinder is not important.

CLAIMS

1. Use of a collapsing at least partial vacuum behind the piston of a piston and cylinder arrangement to provide a forward propelling force to launch a projectile.

2. Use of a tension gas spring to launch a projectile, the tension gas spring comprising a cooperating piston and cylinder arrangement in which at least a partial vacuum is created behind the piston and the piston is coupled to the projectile via a tension element and a releasable coupling, whereby collapse of the vacuum is effective to apply a forward propelling force to the projectile via the tension element and the releasable coupling, the coupling being released at launch velocity of the projectile.

3. Apparatus for launching an unmanned air vehicle or other projectile, comprising a tension gas spring comprising of a cooperating piston and cylinder arrangement in which at least a partial vacuum may be created behind the piston, a tension element coupled to the piston and a releasable coupling for interconnecting the tension element and the vehicle or other projectile and adapted to be released at launch velocity, whereby collapse of said vacuum is effective to apply a forward propelling force to the projectile via the tension element.

4. Apparatus as claimed in Claim 3 wherein the tension element comprises an appropriate cable.

5. Apparatus as claimed in Claim 4 wherein the vehicle or other projectile is mounted on a trolley which is attached to the end of the cable remote from the piston, the trolley comprising the releasable coupling.

6. Apparatus as claimed in Claim 5 comprising a buffer stop adapted to bring the trolley to a stop, thereby to release the vehicle or projectile from the trolley.

7. Apparatus as claimed in Claim 5 or 6 wherein the trolley is wheeled, or arranged to run on rails.

8. Apparatus as claimed in any one of Claims 3 to 7 wherein the piston and cylinder arrangement comprises a cylinder having one closed end.

9. Apparatus as claimed in Claim 8 comprising a suction pump coupled to the closed end of the cylinder.

10. Apparatus as claimed in any one of Claims 3 to 7 wherein the piston and cylinder arrangement comprises a cylinder having two pistons, a primary piston and a contra piston, the vacuum being created behind the primary piston by moving the contra piston along the length of the cylinder to provide a vacuum filled space between the two pistons.

11. Use of a collapsing vacuum to launch a projectile substantially as hereinbefore described.

12. Apparatus for launching a projectile substantially as hereinbefore described and with reference to Figure 1 or to Figures 2 and 3 of the accompanying drawings.

The Patent Office

11

Application No: GB 9418628.5
Claims searched: 1-12

Examiner: C B VOSPER
Date of search: 6 December 1995

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): A6S, B7G

Int Cl (Ed.6): B64F 1/00; F41B 11/00

Other: ONLINE WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB2173745A	DEFENCE (whole document - shows all the features of claims 2-8 except the vacuum-operated tension gas spring)	2-8 at least
A	GB0480692	MITCHELL (whole document)	2-8 at least
X	GB0478427	MITCHELL (page 6, lines 3 to 24)	1
A	GB0470088	MERZ (whole document)	1 at least
A	GB0327101	SALMON (page 5, lines 9 to 19, and 70 to 77)	1 at least
A	GB0195991	LOW (whole document)	2-8 at least
A	US4240599	CORNWELLS/UNITED STATES (whole document)	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

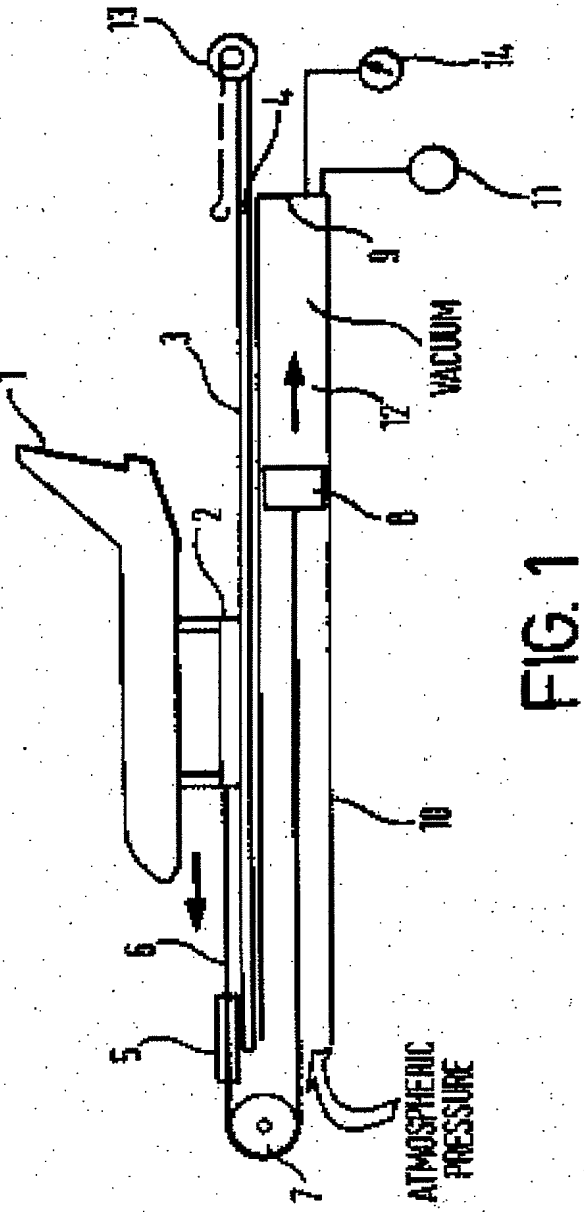
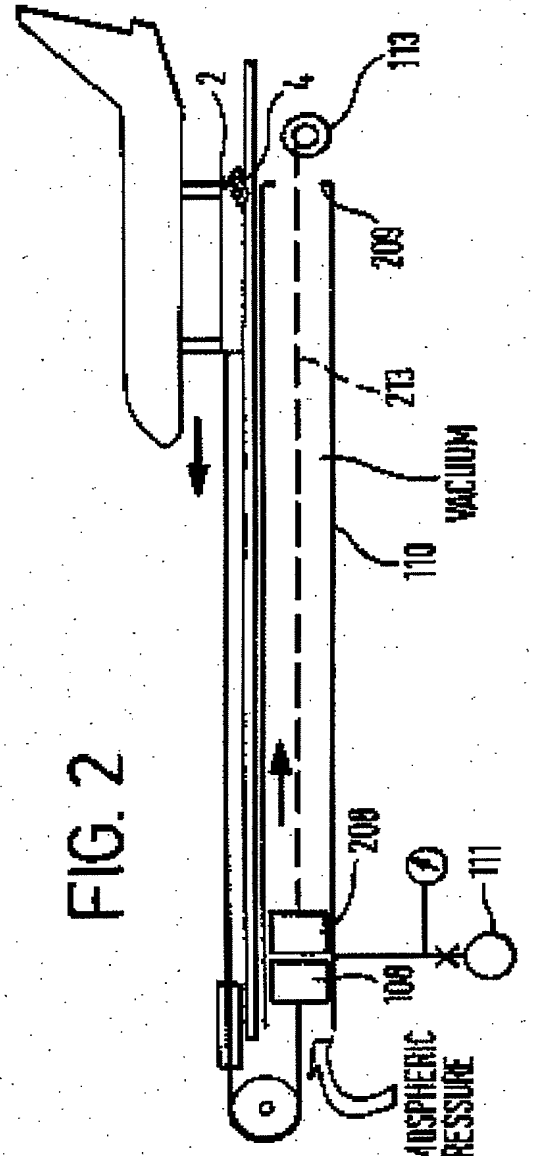


FIG. 1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VACUUM
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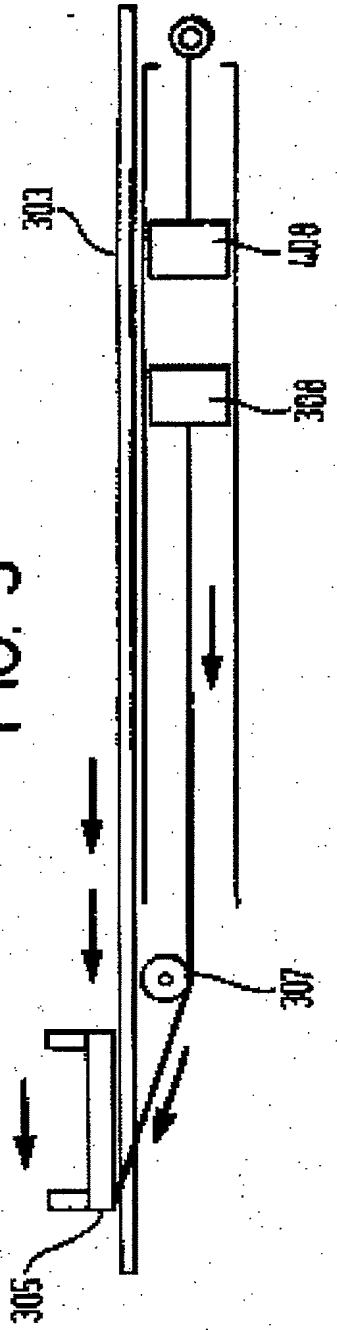
109
ATMOSPHERIC PRESSURE

FIG. 2


303
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305

FIG. 3